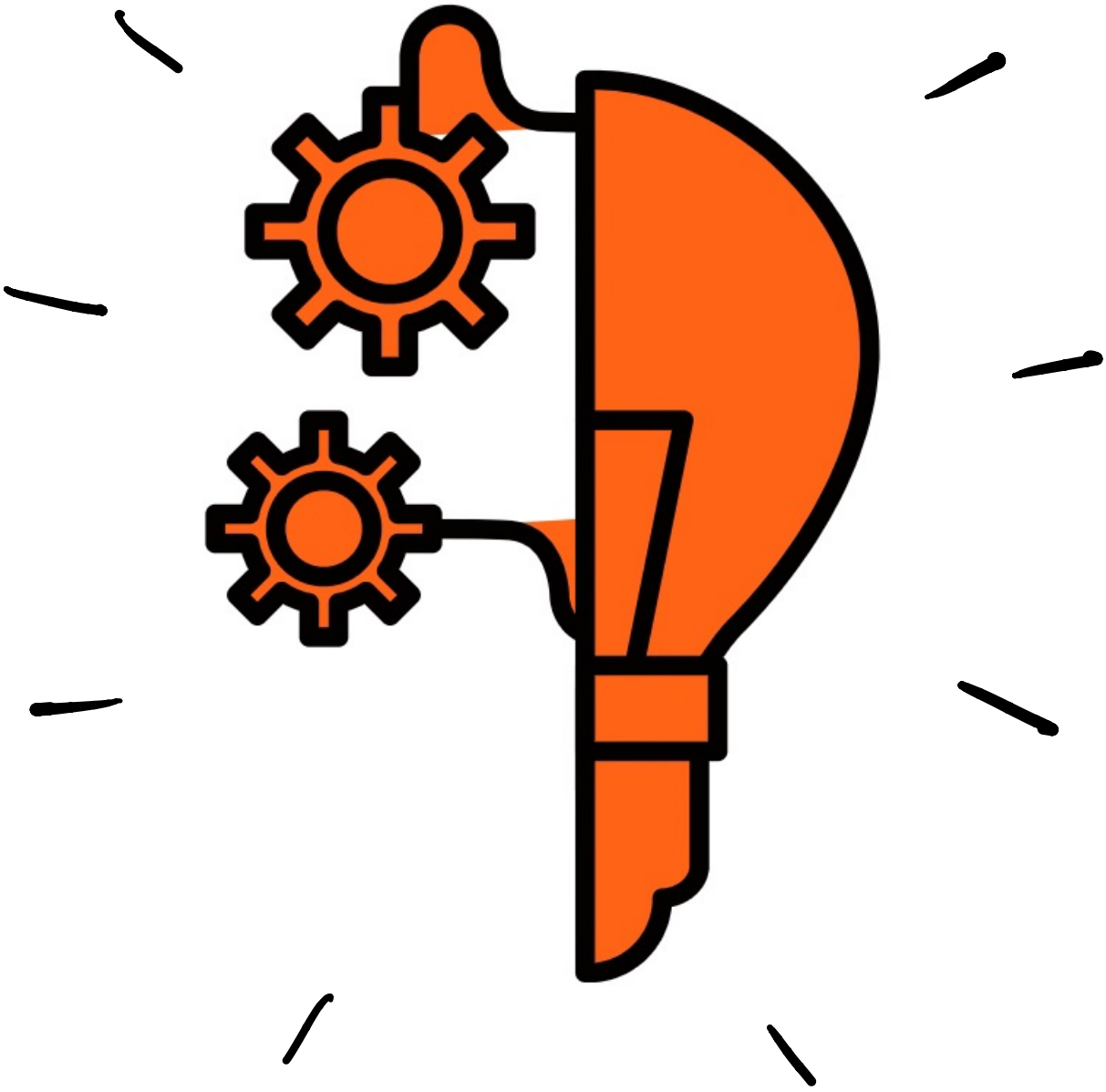
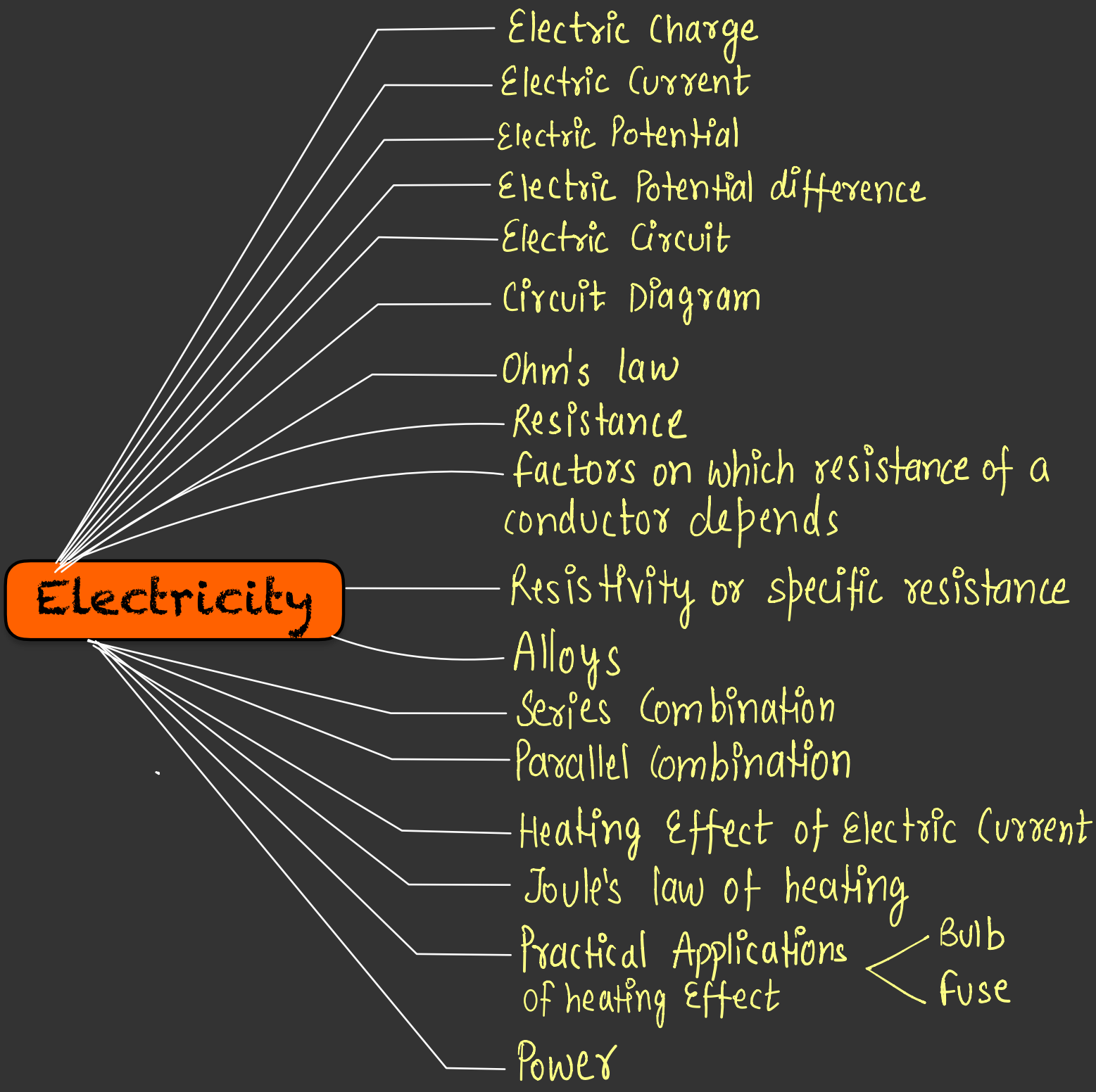
ELECTRICITY

HANDWRITTEN NOTES



Designed With ♥

Shobhit Nirwan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Electric Charge [Symbol ⇒ q]

↳ A physical entity which is defined by excess or deficiency of electron on a body.

- It is a Scalar Quantity.
- SI Unit of charge is Coulomb (C).

Magnitude of Charge on one

- PROTON = $e = +1.6 \times 10^{-19}$ C
- ELECTRON = $e = -1.6 \times 10^{-19}$ C

- As charge on one electron = 1.6×10^{-19}C
  ∴ charge on n electron = $n \times 1.6 \times 10^{-19}$C

i.e. $\boxed{q = n \times e}$

K^3B ⇒ किसी question में no. of electrons निकालने की बात करे तो ये formula click करना चाहिए।

n ⇒ no. of electrons.

Electric Current [Symbol ⇒ I]

↳ The amount of charge 'Q' flowing through a particular area of cross-section in unit time 't'.

- It is a Scalar Quantity
- SI unit of current is Ampere (A). [$1A = 1 \frac{\text{Coulomb}}{\text{Second}}$]

ऊपर वाली definition को ध्यान से देखे तो Current का formula बनता है:-

$$\boxed{I = \frac{Q}{t}}$$

K^3B ⇒ Direction of electric current is taken as opposite to the flow of electrons and अगर circuit दिया हो तो current ⊕ve terminal of battery से ⊖ve terminal की तरफ जाएगा।

- Electric current is measured by a device called Ammeter.

LP: A current of 1A is drawn by a filament of an electric bulb. Find the number of electrons passing through a cross-section of the filament in 16 seconds?

Sol: Given: $I = 1A$
$t = 16$ seconds
To find: no. of electrons??

(कुछ याद आया??)
↳ $q = ne$ लगेगा। but पहले q निकालेंगे।

We know, $I = \frac{Q}{t} \Rightarrow 1A = \frac{Q}{16\,sec} \Rightarrow \boxed{Q = 16C}$

Now, $Q = ne$

$16C = n \times (1.6 \times 10^{-19})$

$\boxed{n = 10^{20}}$

Electric Potential [Symbol ⇒ V]

↳ The amount of work done (W) when a unit positive charge (q) is moved from infinity to a point.

$$\boxed{V = \frac{W}{q}}$$

- It is a Scalar Quantity.
- SI unit is volt (V).

Electric Potential Difference [Symbol ⇒ ΔV]

↳ It measures the work done (W) per unit charge (q). It is defined as the difference in electric potential between two points in an electric field, equal to the work done per unit quantity of charge in moving it from one point to another in an electrostatic field.

$$\text{Potential Difference} = \Delta V = \frac{W}{Q}$$

$$\text{or, } V_b - V_a = \frac{W_{AB}}{Q}$$

- It is a Scalar Quantity.
- SI unit is $\left(\frac{\text{Joule}}{\text{Coulomb}}\right)$ → याद नहीं होती तो formula देख लो, रटना नहीं है 😊

- The electric potential difference between two points in a circuit is measured using a device called Voltmeter.

LP:- How much work is done in moving a charge of 2C from a point of 118V to a point at 128V?

Sol: Given: $Q = 2C$

$V_A = 118V$, $V_B = 128V$ (Assuming that charge is taken from point 'A' to point 'B'.)

To find: $W = ??$

Now, $\Delta V = V_B - V_A = (128 - 118)V = 10V$

(Potential diff.)

$$\Delta V = \frac{W}{Q} \Rightarrow W = (\Delta V)(Q)$$

$$= (10V)(2C) = 20J$$

K³B ⇒ ΔV वाला formula यहां क्यूं लगाया?

↳Ans:- इस question की line पढ़ो, फिर ΔV की definition वाली line पढ़ो, समझ जाओगे 😊

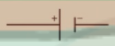
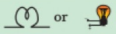
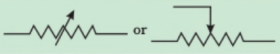
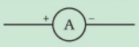
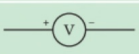
Electric Circuit

↳ A closed and continuous path through which electric current flows is known as electric circuit. It has various components including a source of current (a cell or battery), a load (bulb or any appliance), key (to open or close a circuit), fuse etc, all connected through wires. These wires are generally made of copper.

- When key/switch is closed, then circuit is called closed circuit (i.e. current will flow).
- When key/switch is open, then circuit is called open circuit (i.e. current would not flow)

Circuit Diagram

↳ It is the pictorial representation of a circuit in which different electrical components of the circuit are presented by their symbols.

Sl. No.	Components	Symbols
1	An electric cell	
2	A battery or a combination of cells	
3	Plug key or switch (open)	
4	Plug key or switch (closed)	
5	A wire joint	
6	Wires crossing without joining	
7	Electric bulb	
8	A resistor of resistance R	
9	Variable resistance or rheostat	
10	Ammeter	
11	Voltmeter	

#RattaMaarLo

Symbols for most commonly used electrical components in circuit diagram.

Source: NCERT

Ohm's Law

↳ According to this law, the electric current flowing through a conductor is directly proportional to the potential difference applied across its ends, providing the physical conditions (such as temperature) remains unchanged.

Mathematically: If V is the p.d. applied across the ends of a conductor through which current I flows, then according to Ohm baba:-

$$V \propto I \quad \text{(at const. temp)}$$

or,

$$\boxed{V = IR}$$

R ↑ constant of proportionality called resistance.

K³B ⇒

- The conductors which obeys Ohm's Law are called ohmic conductors while the conductors which do not obey Ohm's Law are called non-ohmic conductors.
- from ohm's Law → $V=IR \Rightarrow R=\frac{V}{I}$

or $R \propto \frac{1}{I}$ (R is inversly proportional to I) (If V → const.)

So, if resistance is doubled, then current gets halfed and if resistance is halved, then current gets doubled.

↳ ये concept काफी जगह काम आ सकता है इसलिए feel लेकर समझना; जब भी V, I या R में से किसी एक value को change करके, दूसरी पर effect पूछे (keeping 3rd as constant) तो समझ जाना ohm बाबा और proportionality काम आएगी।

Resistance [Symbol ⇒ Ω]

↳ Is is that property of a conductor by virtue of which it opposes/resists the flow of charge through it. (आसान भाषा में बोलें तो अपने through current जाने का oppose करता है)

- It is a Scalar Quantity
- SI Unit is ohm or $\left(\frac{\text{volt}}{\text{Ampere}}\right)$

we know ohm's law → $V=IR \Rightarrow \boxed{R=\frac{V}{I}}$

K³B ⇒ FACTORS ON WHICH RESISTANCE OF CONDUCTOR DEPENDS :- [Cbse 2018]

(i) Directly proportional to length of conductor i.e. $\boxed{R \propto l}$ — (I)
(ii) Inversly proportional to area of crossection of conductor i.e. $\boxed{R \propto \frac{1}{A}}$ — (II)
(iii) Nature of material
(iv) Temperature.

Combining eq (I) & (II) ⇒ $R \propto l \propto \frac{1}{A}$ or $R \propto \frac{l}{A}$ or ** $\boxed{R=\rho\frac{l}{A}}$

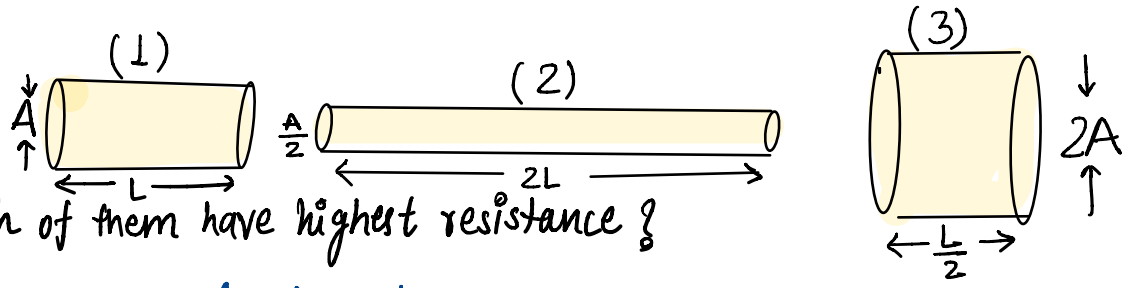
ρ ← Constant of prop. called Resistivity.

Resistivity or Specific resistance [Symbol ⇒ ρ]

↳ Resistance of a conductor of unit-length and unit area of cross-section.

- SI unit is Ω-m (ohm-meter)
- Resistivity of metallic conductor does not depend on the length or thickness of wire.
- Metals have low resistivity. So, they are the best conductor of current.

K³B ⇒ Alloys have higher resistivity than that of their constitvent metals. They do not oxidise easily at higher temp, this is why they are used to make heating elements of devices such as Iron, heaters etc. Tungsten is almost used exclusively for filment of bulbs, whereas copper and aluminium are generally used for electric transmission lines. [Cbse 2018]

LP:- 

All 3 are made up of same material.

Which of them have highest resistance ?

Sol:- Given are length and area of cross-section of each conductor.
↳ (obvious है कि $R=\frac{\rho l}{A}$ वाले formula का use होगा।) → Imp. conclusion

Also given that all 3 are of same material, ∴ ρ will be same for all.

Now, (i) $R_1 = \rho\left(\frac{L}{A}\right)$

(ii) $R_2 = \rho\left(\frac{2L}{A/2}\right) \Rightarrow 4\left(\frac{\rho L}{A}\right) \Rightarrow 4R_1$

(iii) $R_3 = \rho\left(\frac{L/2}{2A}\right) \Rightarrow \frac{1}{4}\left(\frac{\rho L}{A}\right) \Rightarrow \frac{R_1}{4}$

Hence, $R_2 > R_1 > R_3$

R_2 have highest resistance.

LP:- A piece of wire of resistance 20Ω is drawn out so that its length is increased to twice its original length. Calculate resistance of wire in the new situation.

sol :- Initially :- let length = l & area of cross section = A & resistivity = ρ

$R_i = \frac{\rho l}{A} = 20$ (given) — (I)

finally, ATQ :-

↳ Read point of resistivity ??

Now, $R_f = \rho\frac{(2L)}{(A/2)} = 4\left(\frac{\rho L}{A}\right)$

$= 4(20) \Rightarrow 80\Omega$ (from I)

K^3B ⇒ $R=\frac{\rho l}{A}$ में A = area है, जब भी question में radius(r) या diameter(d) दिया हो area of cross section circle का area वाले formulae से निकाल लेना because wire का crossection तो circle होता है ना! ☺ → circle

LP:- The potential diff between the terminals of an electric heater is 60V when it draws a current of 4A from the source. What current will the heater draw if potential difference is increased to 120V ?

sol:- As we know that changing potential difference will not change resistance.

Initially, $V=60V$, $I=4A$

by ohm's law, $V=IR \Rightarrow 60=4(R) \Rightarrow \boxed{R=15\Omega}$

finally, $V'=120V$, $R=15\Omega$

to find $I=??$

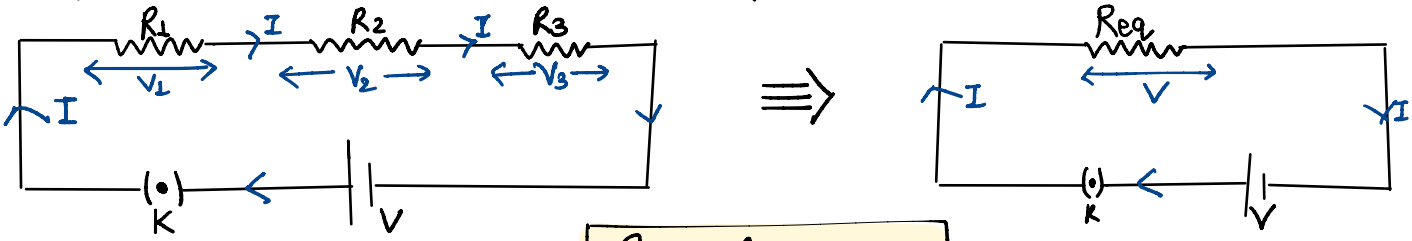
again using ohm's law, $V'=I'R$

$120 = I'(15)$

$\boxed{I'=8A}$

Series Combination

- सारे Resistances end to end attached हों and सबमें same current होगा।

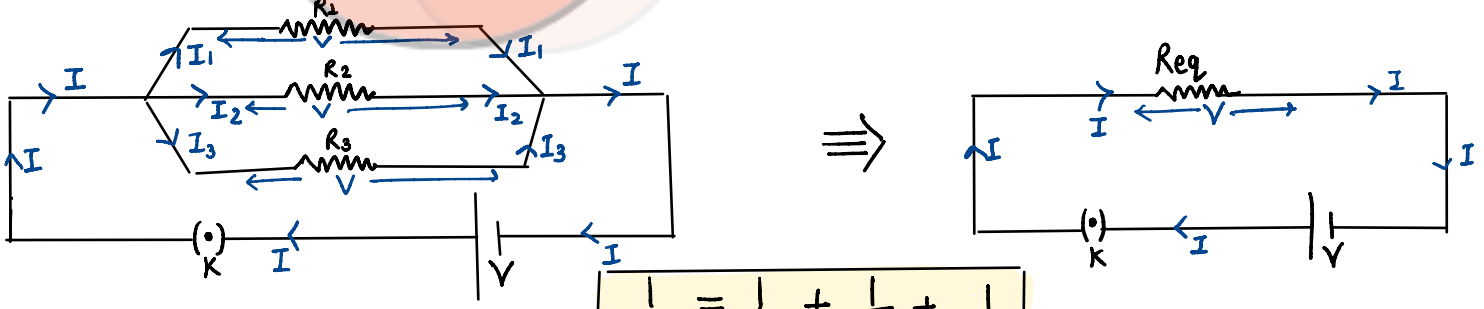


$$R_{eq} = R_1 + R_2 + R_3$$

K³B ⇒
- Equivalent resistance is the sum of all the resistances connected in series.
- Equivalent resistance is greater than the resistances of either resistor, ∴ जब भी Resistance maximize करना हो तो series में लगा दो उन्हें। (cbse 2020)
- Series में हर Resistance के across ⇒ I → same, V → different
- Disadvantages of series: (i) If any component fails to work then the circuit will break and none of them will work. (ii) We cannot connect bulb and heater in series because they need different values of current.

Parallel Combination

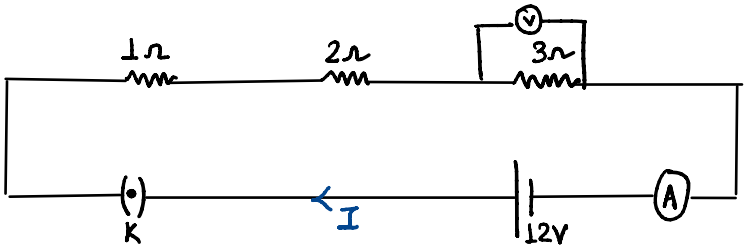
- सारे Resistances के across V (potential difference) same रहेगा।



$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

K³B ⇒
- The reciprocal of equivalent resistance is equal to the sum of the reciprocals of all individual resistances connected in parallel.
- The equivalent resistance is less than the resistance of either resistor, ∴ जब भी Resistance minimize करना हो तो उन सबको Parallel में लगा दो
- Parallel में हर Resistance के across ⇒ V → same, I → different
- As it divides the current among the components (electric gadgets), so that they can have necessary amount of current to operate properly. This is the reason of connecting electrical appliances in parallel combination in household circuits.

LP:-



Find (i) Reading of Ampere
(ii) Reading of Voltmeter
(iii) Current across 1Ω resistor

Sol:- Since they all are in series ∴ I → same & V → diff.

Now, $R_{eq} = R_1 + R_2 + R_3 \Rightarrow 6\Omega$

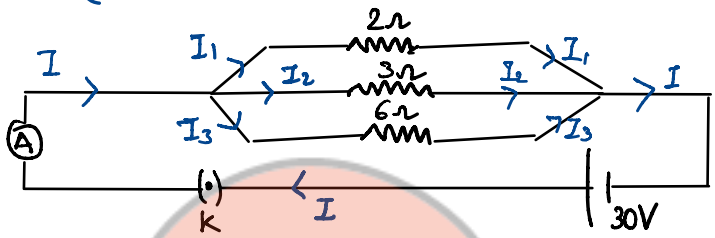
by ohm's law $\Rightarrow V = IR_{eq}$

$12 = I(6) \Rightarrow \boxed{I = 2A}$ — (i) this is the reding of (A)

(ii) Voltmeter will give potential difference (V) across 3Ω resistance.
and we already know current (I) = 2A
∴ Again by ohm's law, $V = IR$
$V = (2)(3) \Rightarrow 6V$ → (ii) reading of (V)

(iii) 2A (∵ all will have same current as they are in series).

LP:-



find current in each resistance. and in ammeter.

Sol:- Since they all are in parallel, ∴ V → same and I → diff.

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \Rightarrow \boxed{R_{eq} = 1\Omega}$

Now, by ohm's law: $V = IR_{eq}$

$30 = I(1) \Rightarrow \boxed{I = 30A}$ → this will be the reading of (A)

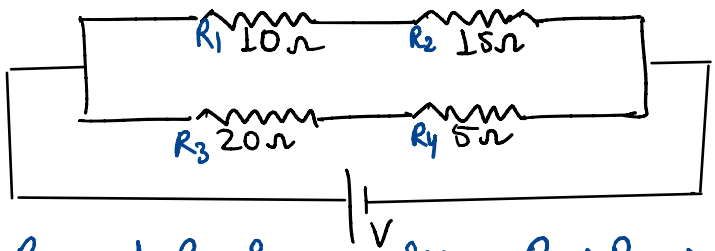
As they all are in parallel, ∴ all will have same V i.e. 30V
Now, we'll find current in all by using simply ohm's law:-

→ for 2Ω, $I_1 = \frac{V}{R} = \frac{30}{2} \Rightarrow 15A$

→ for 3Ω, $I_2 = \frac{V}{R} = \frac{30}{3} \Rightarrow 10A$

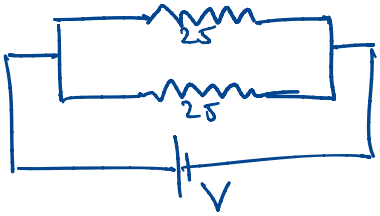
→ for 6Ω, $I_3 = \frac{V}{R} = \frac{30}{6} \Rightarrow 5A$

LP:-



Calculate net resistance of circuit

Soln:- R_1 and R_2 in series $= R_1 + R_2 \Rightarrow 25\Omega$, $R_3 + R_4 = 25\Omega$
∴ above circuit can be



→ Now both in parallel

$\frac{1}{R_{eq}} = \frac{1}{25} + \frac{1}{25}$

$\boxed{R_{eq} = 12.5\Omega}$

Heating effect of Electric Current

↳ In an electric circuit, to maintain the flow, the source continuously has to provide the energy. Some part of this supplied energy helps in maintaining the current, rest of it may be dissipated in form of heat. This is known as heating effect of electric current.

Joule's law of Heating

[cbse 2020, 2018]

↳ This law implies that heat produced in a resistor is:
(i) directly proportional to square of current in resistance i.e. $H \propto I^2$ — (I)
(ii) directly proportional to the resistance for a given circuit i.e. $H \propto R$ — (II)
(iii) directly proportional to the time for which current flows i.e. $H \propto t$ — (III)

from (I), (II) & (III) $\boxed{H = I^2 R t}$ $t \rightarrow$ in seconds

K^3B ⇒ PRACTICAL APPLICATIONS OF HEATING EFFECTS:-

- To produce light (Electric Bulb): It has a filament made of tungsten, Due to high resistivity and high melting point of tungsten, when voltage is applied across the filament it gets heated to a very high temperature. It then becomes white hot and starts radiating heat and light.

- Electric Fuse: It is used as a safety device in household circuits. It consists of an alloy of lead and tin which has appropriate melting point. When the current flowing through the circuit exceeds the safe limit, the temp. of fuse wire increases, the fuse wire melts and breaks the circuit. This helps to protect the other circuit elements from hazards caused by currents.

Q: 200J of heat is produced 10sec in a 5Ω resistance. Find the potential diff across the resistor.

Sol: Given: $H = 200J$, $t = 10s$, $R = 5\Omega$

Joule's law, $H = I^2Rt$

$200 = I^2(5)(10)$

$\boxed{I = 2A}$

Now for V, using ohm's law

$V = IR$

$V = (2)(5) = 10V$

for chapterwise previous year questions, please visit our channel → Shobhit Nirwan.

Power [Symbol ⇒ P]

↳ It is defined as the amount of electric charge consumed in a circuit per unit time

- It is a Scalar Quantity.
- SI unit is watt (W).

$\boxed{P = VI}$ — using ohm's law → $V = IR \rightarrow P = (IR)I = I^2R$; $I = \frac{V}{R} \rightarrow P = V\left(\frac{V}{R}\right) = \frac{V^2}{R}$

इस form में भी आप आ सकता है।

$$P = VI = I^2R = \frac{V^2}{R}$$ [cbse 2020, 2019, 2018]

- 1 kilowatt (kW) = 10^3 W
  1 megawatt (MW) = 10^6 W
  1 gigawatt (GW) = 10^9 W
  1 horse Power (HP) = 746 W

- $E = Pt$ (E: energy)

- Commercial Unit of Electrical Energy
  1 kWh = 1000 Wh
  = 1000 × 3600 Ws
  = 3.6×10^6 Ws or 3.6×10^6 J

- Number of units consumed by electric appliance = $\frac{\text{watt} \times \text{hours}}{1000}$

LP: An electric bulb runs from the 220V mains. The current flowing through it is 0.6A. At what rate is the electrical energy transformed by the bulb? How much energy is transformed in 2 min?

sol: Given; V = 220V and I = 0.6A, t = 2min = 120sec

Rate of Energy Transformed/Power (P) ⇒ VI = 220 × 0.6
= 132 W

Energy Transformed (E) ⇒ Pt = 132 × 120
= 15840 J

LP: An Electric Refrigerator rated 500W operates 6 hours/day. What is the cost of energy to operate it for 30 days at ₹4.5 per kWh?

sol: Energy consumed by refrigerator in 30 days = 500 W × 6 $\frac{\text{hour}}{\text{day}}$ × 30 days
= 90000 Wh ⇒ 90 kWh

∴ Cost of energy to operate the refrigerator for 30 days = 90 kWh × ₹4.5 per kWh
= ₹405